Europlanet TA Scientific Report

PROJECT LEADER

Project number: 22-EPN3-061
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TA Facility visited: TA1 Facility 1 – Iceland Field Sites, Matis

Project Title:

Scientific Report Summary.

(plain text, no figures, maximum 250 words, to be included in database and published)

Iceland provides access to a great variety of environments that are widely considered potential analogues of hydrothermal processes on Mars). Previous investigation revealed a wide variety of microbial communities proliferating at the water side of Krysuvik and Hveradalir hydrothermal systems. Although providing crucial information on the dynamics of extremophilic life, the lack of low altered mineralogical samples prevented from: 1) fully comprehend the hydrothermal weathering dynamics of the primary rock (extrusive Fe-rich basaltic lava), and 2) determine the relation between microbial proliferation and the degree of hydrothermal alteration of the hosting mineral substrate.

As these two aspects are of key importance to understand the habitability potential of the ancient hydrothermal systems found on Mars, Marco Veneranda and Guillermo Lopez Reyes performed a new campaign of analysis to address these two topics. On one hand, the two researchers investigated the mineralogical composition of the two analogue sites by using a portable emulator of the RLS Raman spectrometer onboard the ESA/ExoMars rover. Afterwards, a novel device for the automated synthesis of SERS nanoemulsions was used to investigate the organic content of the hydrothermal waters. The obtained results were then used to select optimal geological and biological samples to be returned in the laboratory for further investigation. As a whole, this research project aims at supporting the RLS team in defining and optimizing the potential scientific outcome of the RLS instrument once it will be operated on the surface of Mars.

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Description of the campaign

Marco Veneranda and Guillermo Lopez-Reyes performed investigation at the hydrothermal areas of Krýsuvik (coordinates: 63.896051, -22.053625) and Hveradalir (coordinates: 64.020375, -21.397360). After visual inspection, the two researchers made use of portable analytical instruments (including Raman spectroscopy and X-Ray diffractometry) to investigate the mineralogical composition of geological units found in the proximity of the hydrothermal springs these showing high level of alteration (see Figure 1). Furthermore, additional rock samples were analysed at several meters of distance from the hydrothermal area to identify the primary minerals of unaltered rocks.

Figure 1: Image of the hydrothermal stream of Hveradalir.

Concerning Raman analysis, two spectrometers were used. On one hand, the researchers employed the microRaman from Lightnovo, these being the most compact Raman spectrometer in the market (see Figure 2). On the other hand, the RAD1 portable instrument was used, these being a portable emulator developed by the team to closely emulate the scientific performance of the RLS instrument onboard the ExoMars Rosalind Franklin rover.

As for XRD analysis, the XTERRA diffractometer was used, this being a commercial version of the CheMin instrument that has been operated on Mars during the MSL/Curiosity mission.

Figure 2: Molecular analysis performed in-situ by using a portable Raman spectrometer.

Based on the preliminary mineralogical results obtained by in-situ analysis, geological samples showing different degree of hydrothermal alteration were collected to be further analyzed in the laboratory

As represented in Figure 3, clear biological patinas were found in the proximity of the hydrothermal water streams with temperatures up to 65 ºC, this proving the proliferation of extremophilic organisms.

Figure 3: Image of green patinas developing in the proximity of the hydrothermal water stream.

Knowing the identification biological patinas would imply the presence of organic molecules in the water stream, samples of water were collected in the proximity of the green areas to perform in-situ SERS analysis. To do so, the SERS prototype displayed in Figure 4 was used. After filtering, the water samples were placed inside a 10ml falcon tube, which was connected to the microfluidic device for automated SERS analysis. As described in the proposal, the device automatically mix the reagents needed to synthesize a plasmonic colloid which is eventually mixed with the hydrothermal liquid samples. Once mixed, the sample is then analysed using the RAD1 Raman spectrometer.

Figure 4: Image of the prototype developed by the team of researchers to perform in-situ, automated SERS analysis of liquid samples.

In-situ SERS analysis allowed the detection of Raman peaks associated to the presence of organic material. However, a more detailed interpretation of the observed spectroscopic features will be carried out in the laboratory.

Beyond in-situ analysis, samples of both biological patinas and hydrothermal water were collected to be further analysed in the laboratory. A total of 19 samples were collected from the hydrothermal area of Krýsuvik (15 geological samples and 4 water samples), while 14 samples were collected from Hveradalir (9 geological samples and 5 water samples).
The analysis to be performed in the laboratory are detailed below:

- The mineralogical composition of the samples will be further characterized by the RLS-Sim, that is the instrument used that most closely emulate the scientific outcome of the RLS onboard the ExoMars rover.
- The bulk organic geochemistry of the samples will be measured and combined to molecular and isotopic lipid analysis. This will be done by following the procedure applied by the CAB team on geothermal samples collected in previous expeditions.
- Organics will be extracted by the sample preparation unit (SPU) of the SOLID3, thus replicating the automated procedure that could be used on Mars.
- The microfluidic prototype will be used for the automated synthesis of plasmonic nanoemulsions and their mixture with the sample extracts.
- After coupling the microfluidic prototype to the RLS-Sim, SERS analysis will be performed to identify the potential presence of biosignatures.

- By combining the preliminary data collected in-situ with the sample characterization to be performed in the laboratory, the research team foresee the publication of at leas two scientific articles in high impact factor journals. The first manuscript will focus on the mineralogical characterization of the geological units found at the two hydrothermal sites, while the second will focus on the SERS analysis of the organic molecules preserved within the hydrothermal fluids. A further work, based on the extraction of organics from geological samples, will be also presented as poster communication in an international congress (e.g. GeoRaman 2024)

- Host confirmation

Please can hosts fill in/check this table confirming the breakdown of time for this TA project:

Dates for travel to accommodation for TA visit (if physical visit by applicant)	Start Date of TA project at facility	Number of lab/field days spent on TA Visit pre-analytical preparation	Number of days in lab/field site for TA Visit	Number of days spent in lab for TA Visit data analysis	End Date of TA project at facility	Dates for travel home (if physical visit by applicant)
Departed: 23-07-2023 (both) Arrived: 23-07-2023 (Veneranda) 24-07-2023 (Lopez-Reyes)	24-07-2023	1	6	0	30-07-23	Departed: 30-07.2023 (Lopez-Reyes) 01-08-2023 (Veneranda) Arrived: 30-07.2023 (Lopez-Reyes) 01-08-2023 (Veneranda)

The host is required to approve the report agreeing it is an accurate account of the research performed.

Host Name	**René Groben, Matís ohf.**
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Date	**11.08.2023**

- Project Leader confirmation

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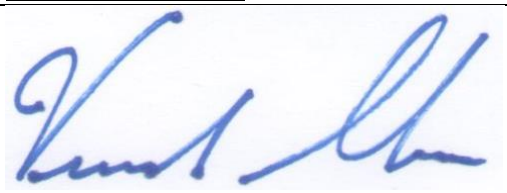
Project Leader Name	**Marco Veneranda**
Project Leader Signature	
Date	**10/08/2023**